

# Digital Image Communication

**Thomas Wiegand**

Course at Technical University of Berlin  
WS 2007/2008



*Contact:*

Dr.-Ing. Thomas Wiegand  
Image Processing Department  
Fraunhofer Institute for Telecommunications  
Heinrich-Hertz-Institut  
Einsteinufer 37, 10587 Berlin

E-mail: [wiegand@hhi.fhg.de](mailto:wiegand@hhi.fhg.de)  
URL: <http://iphome.hhi.de/wiegand>

Tel: 030 - 31002 617  
Fax: 030 - 392 72 00

---

Picture: "Hotel", 720x576, 414,720 Byte

---



---

# JPEG-2000 Compressed to 12,960 Byte

---



---

# JPEG-2000 Compressed to 3,240 Byte

---

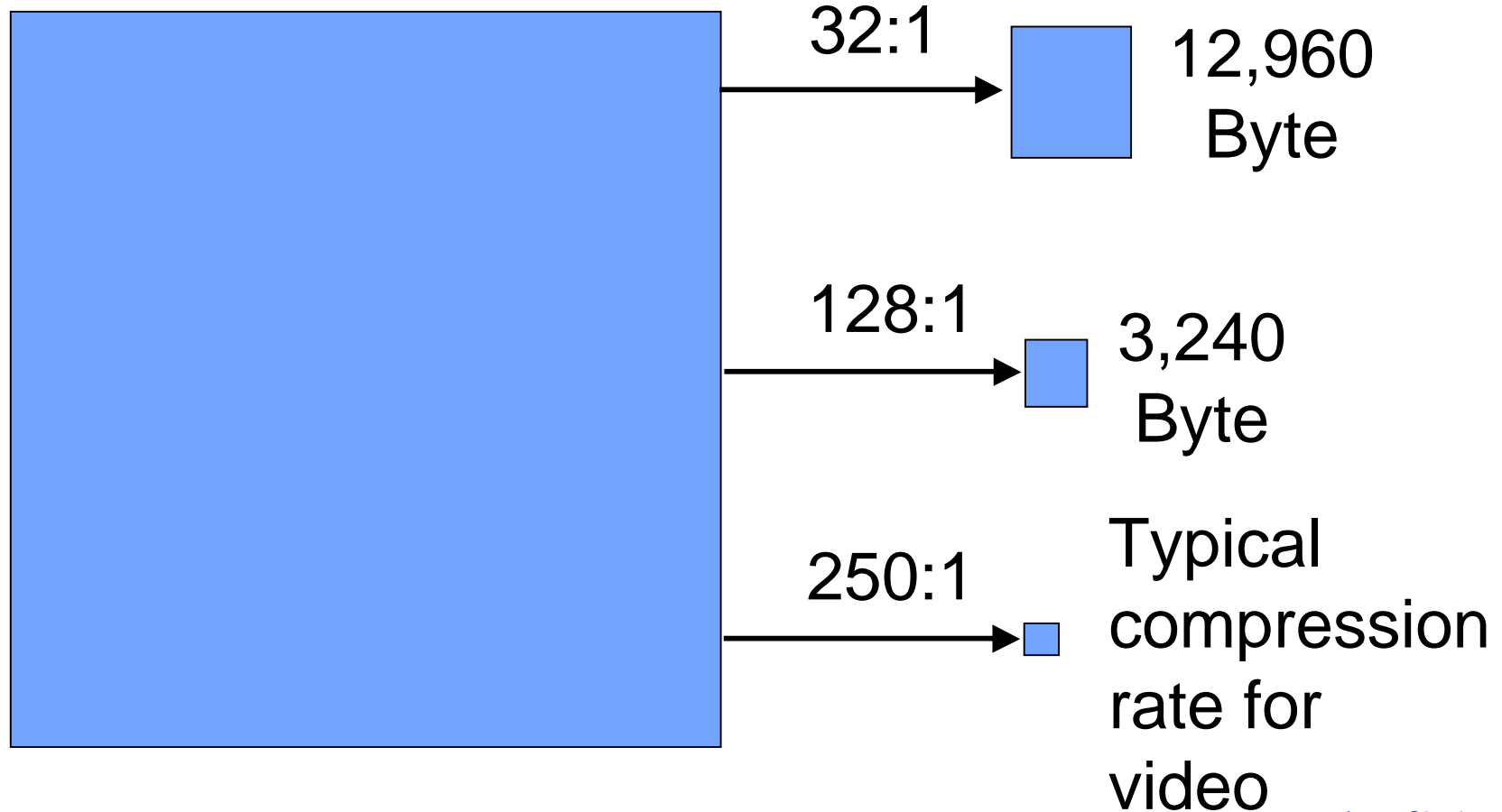


---

# Geometric Interpretation

---

414,720 Byte



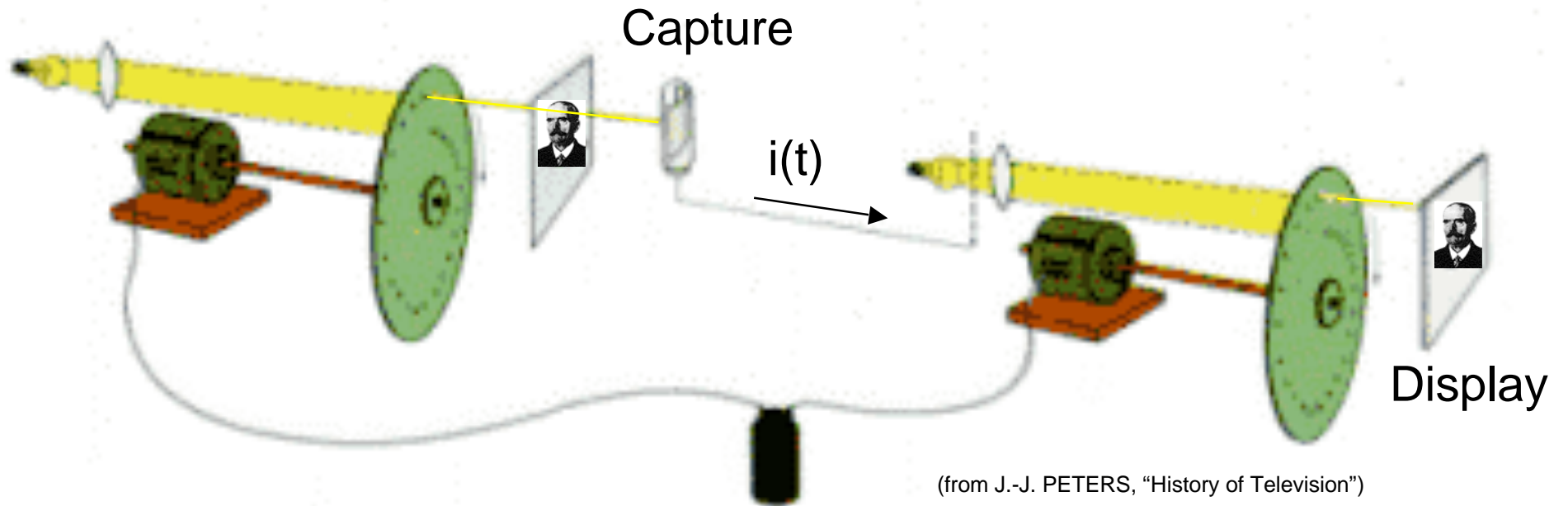
from: Girod

---

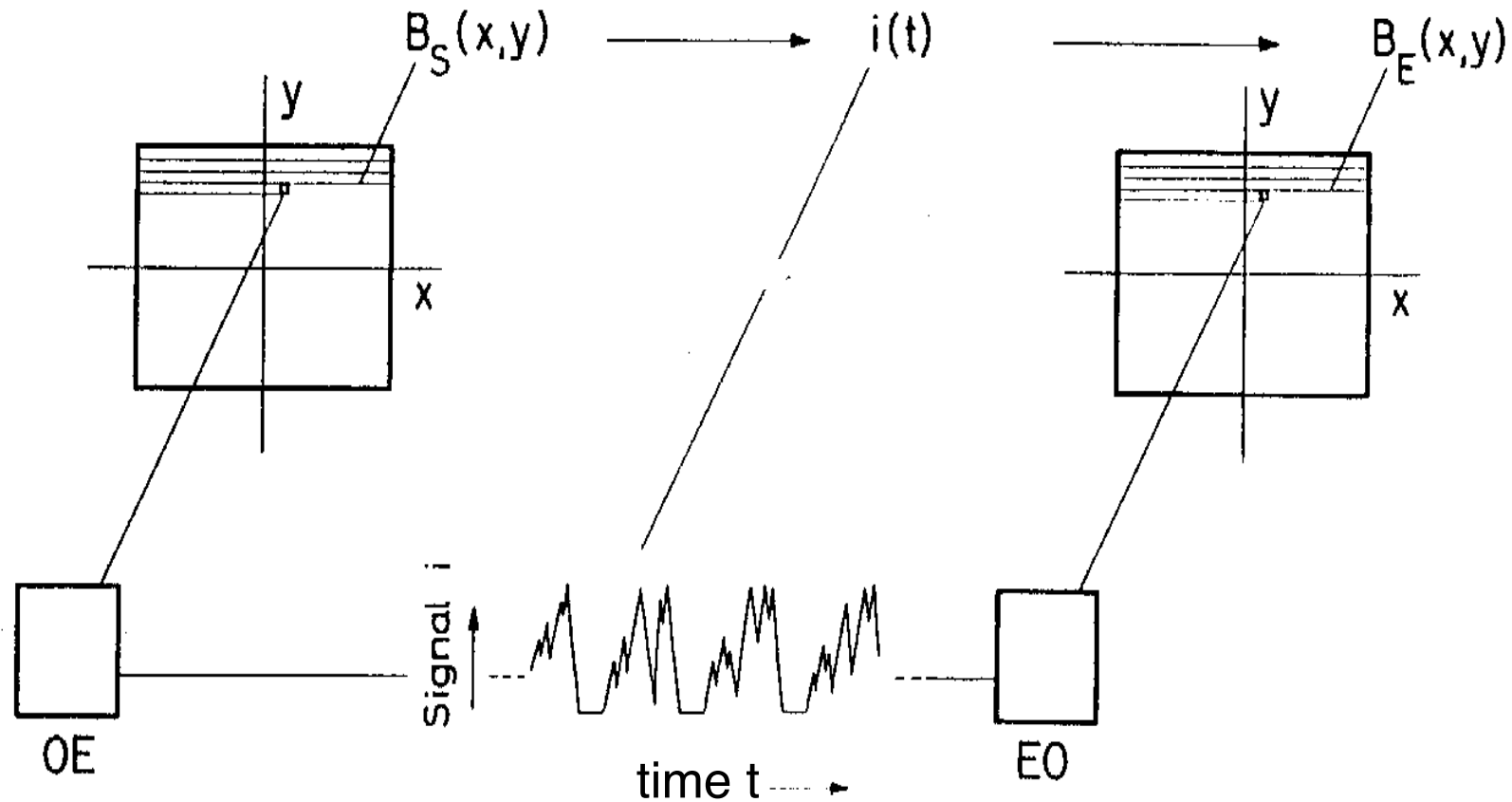
# Nipkow Disk

---

Paul Nipkow: "Elektrisches Teleskop",  
German Patent 1884.



# Image Transmission by Line Scanning

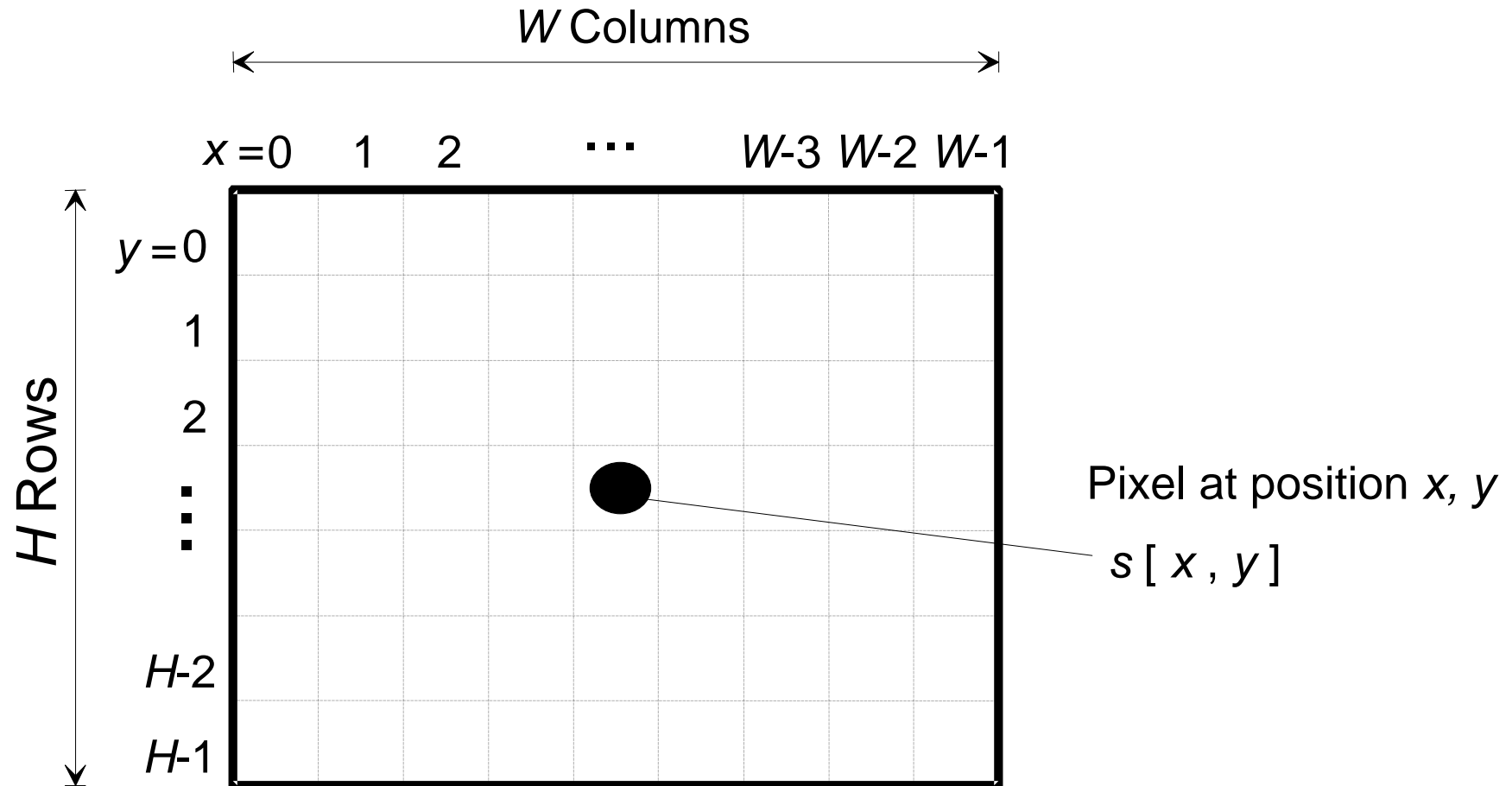


from: Theile

---

# The Image Matrix

---

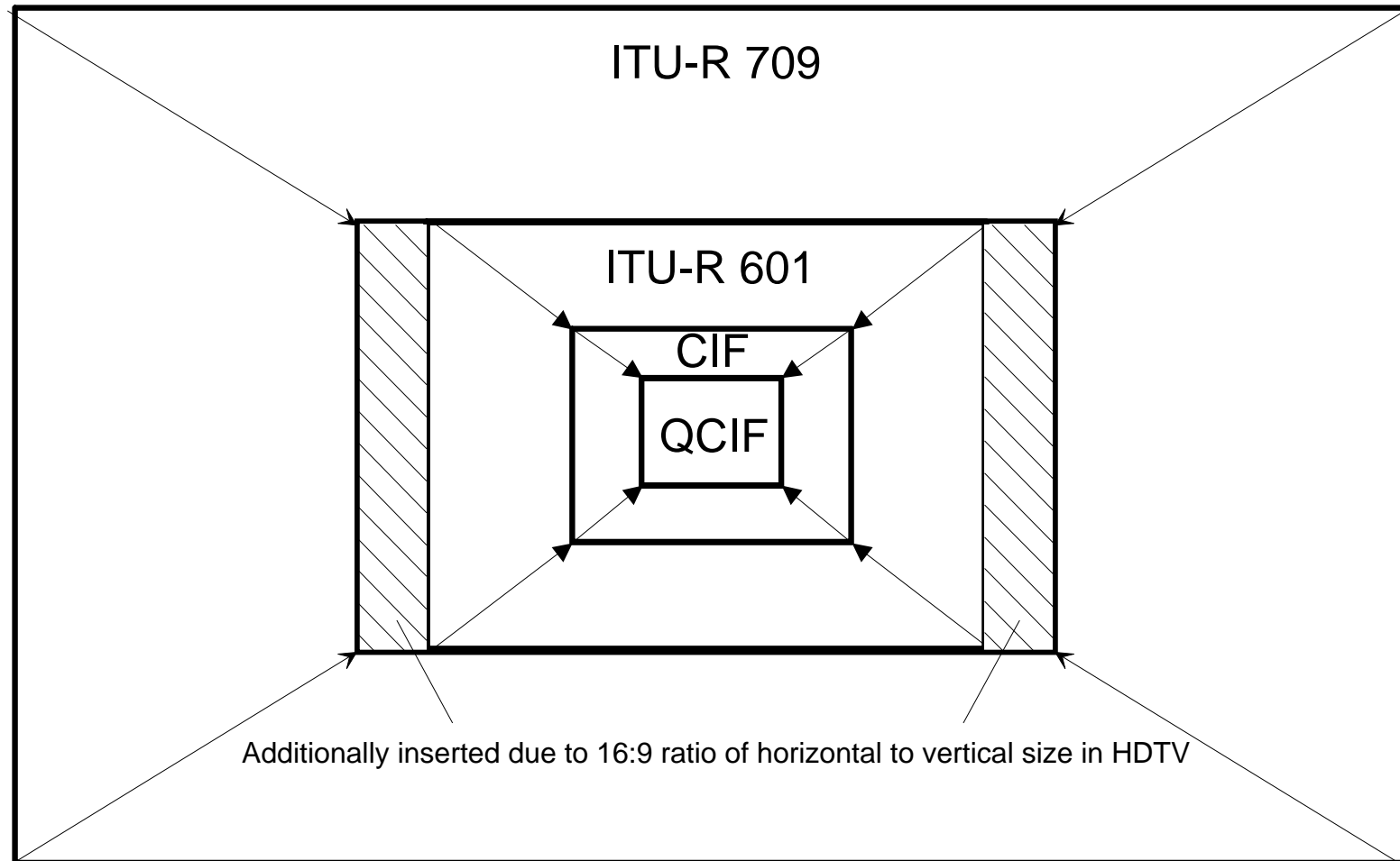


from: Ohm

---

# Digital Image Formats I

---

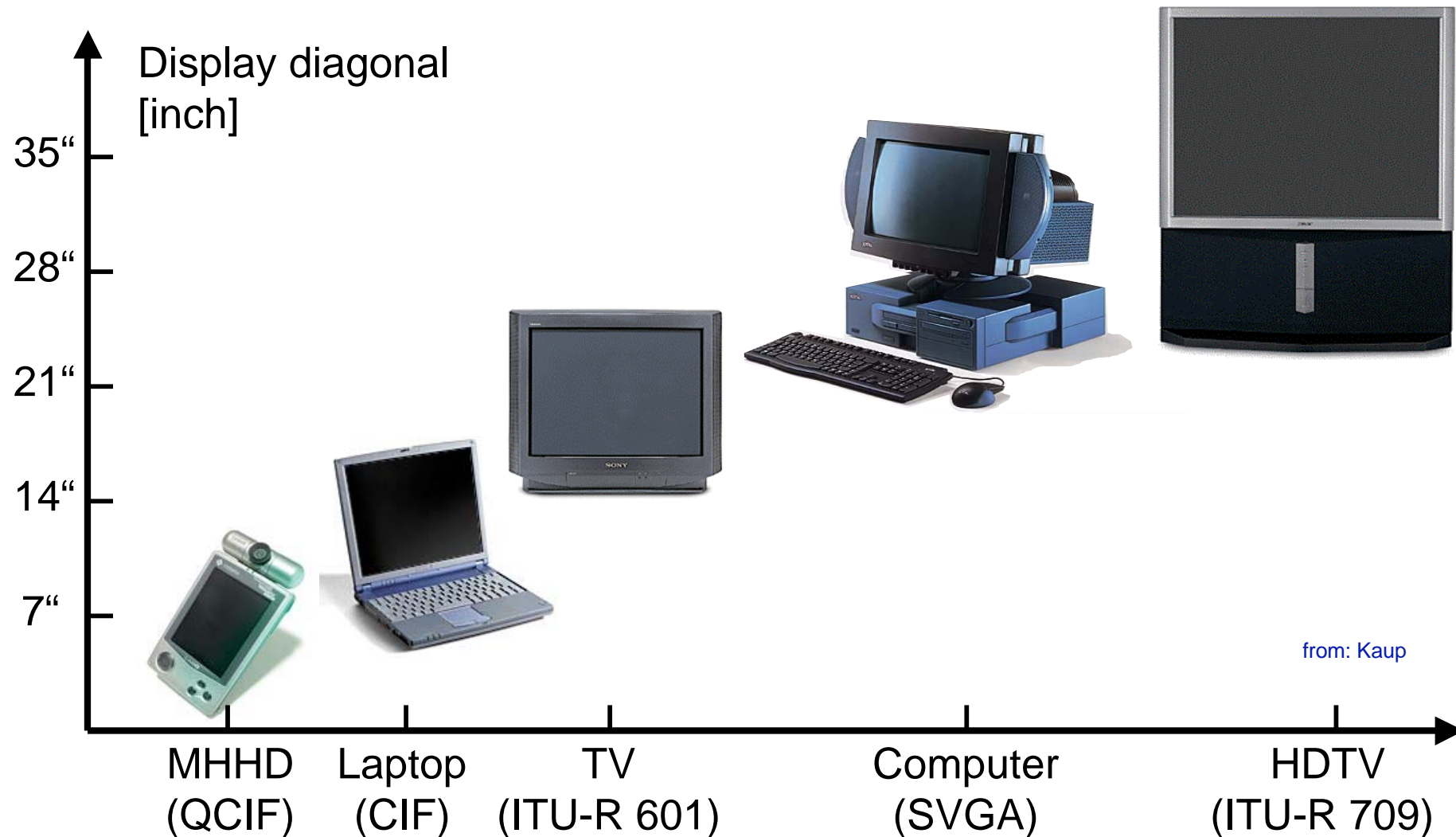


from: Ohm

# Digital Image Formats II

	<i>QCIF</i>	<i>CIF</i>	<i>ITU-R 601</i>	<i>ITU-R 709</i>
Pixel / row ( <i>Y</i> )	176	352	720	1920
Number of rows ( <i>Y</i> )	144	288	576 (480)	1080
Pixel / row ( <i>U, V</i> )	88	176	360	960
Number of rows ( <i>U, V</i> )	72	144	576 (480)	1080
Aspect ratio	4:3	4:3	4:3	16:9
Pictures per second [ <i>Hz</i> ]	5-15	10-30	25 (30)	25 (30)
Bits per picture [ <i>kbyte</i> ] bei 8Bit-PCM	38,02	152,1	829,4 (691,2)	4.424 (3.686)
Bit-rate for image sequence [ <i>Mb/s</i> ]	0,84 - 3,8	10,1 - 30,4	165,9	884,7

# Digital Image Formats and Applications



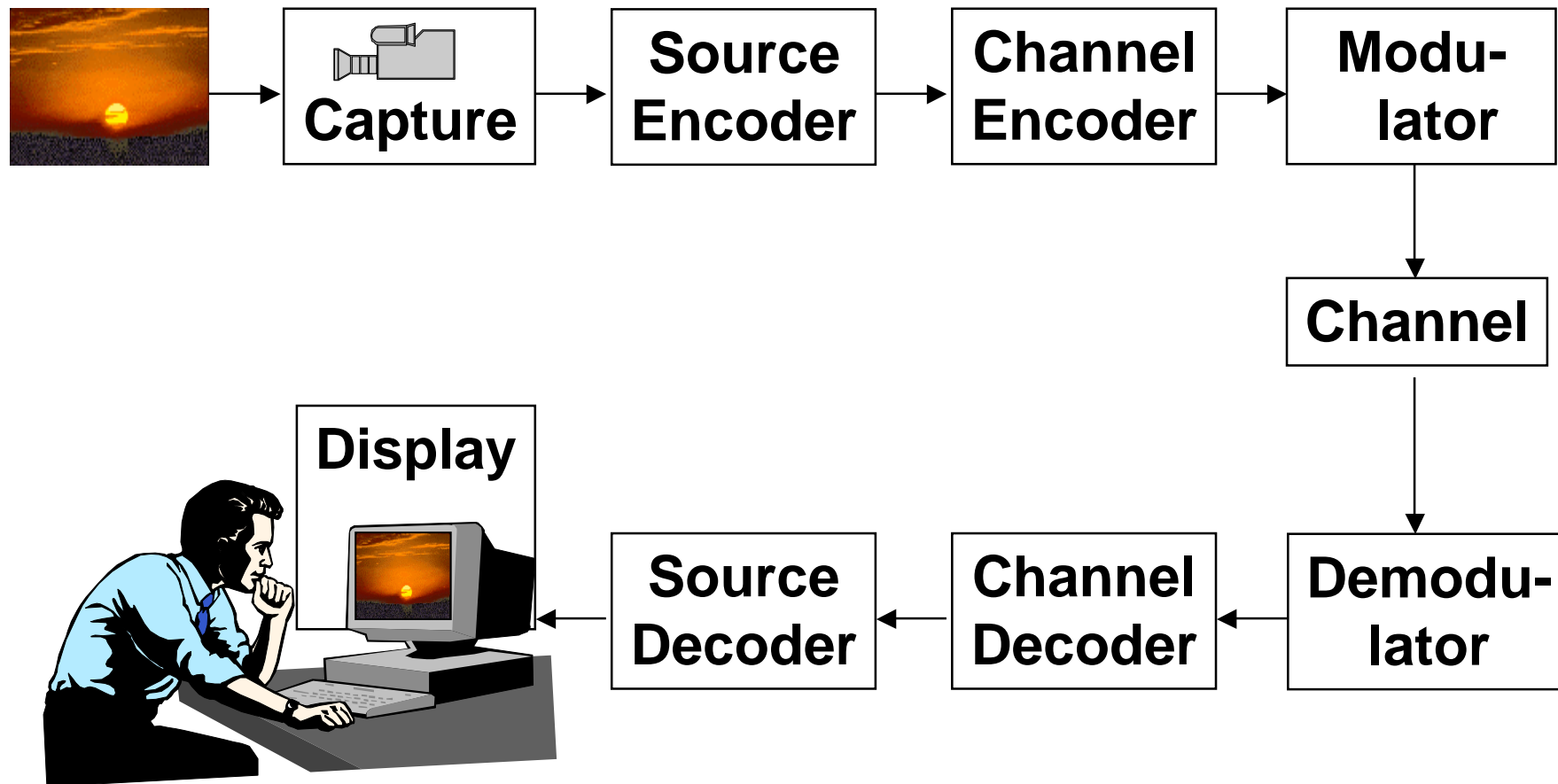
# Examples for Transmission Media

Media	Bit-Rate	Number of pictures that can be transmitted per second in uncompressed format			
		QCIF	CIF	CCIR-601	CCIR-709
Voice Modem	33.4 kb/s	0.11	0.03	0.005	0.001
ISDN	64 kb/s	0.21	0.05	0.010	0.002
T1 (24xISDN)	1.544 Mb/s	5.1	1.3	0.2	0.04
Ethernet	10 Mb/s	32.9	8.2	1.5	0.28
FDDI	100 Mb/s	328.7	82.2	15.1	2.83
GSM	15 kb/s	0.05	0.01	0.002	0.0004
UMTS	384 kb/s	1.3	0.32	0.06	0.01

---

# Transmission System

---



---

# Optimum Scenario

---

**Minimize costs of the complete transmission system, so that the visual information is perceived by the human observer with the desired quality.**

*Problems:*

- Desired accuracy differs for the various applications
- Different applications permit different costs
- Transmission system is interfered by others
- Horizontal integration: design system components separately (How about storage applications ?)
- How can we measure perceived quality ?

---

# Why Digital Image Communication ?

---

- Separation of source coding and channel coding allows independent adaptation to the
  - Properties of information source and sink
  - Properties of the transmission channel
- Digital circuitry allows very large scale integration and low manufacturing costs
- Today, signals are stored and transmitted over digital media

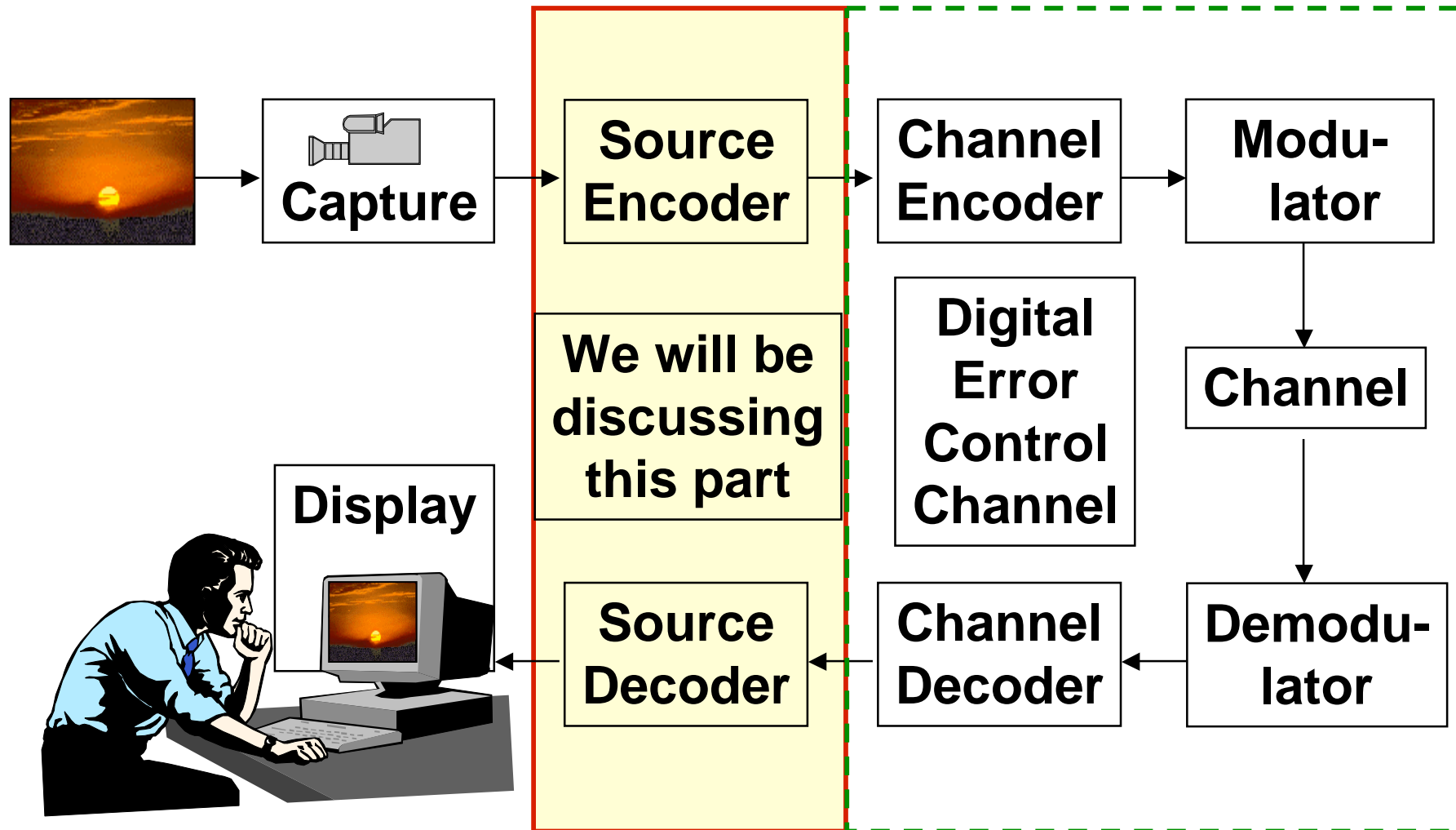
---

# The Human Visual System (HVS)

---

- Resolution limits:
  - Textures with frequencies higher than the limit of the HVS are not recognizable
  - Resolution limits for color are much lower than for luminance
  - Resolution limits are higher for horizontal and vertical structures than for diagonal structures
  - Still objects are recognized much sharper than moving objects
  - Temporal resolution limit of the eye: flicker
- Contrast recognition at edges:
  - Contrast changes at edges are enhanced
  - The HVS is especially sensitive to edges
- Seeing:
  - Combining color, motion, and depth into a collection of interferences about the world
  - Regions of interest in images and videos (various dependencies)

# Scope of this Lecture



---

# Digital Image Communication

---

- Information and Entropy
- Rate Distortion Theory and Quantization
- Predictive Coding
- Transform Coding
- Resolution Pyramids and Subband Coding
- Image Coding Standards JPEG, JPEG-2000
- Hybrid Video Coding
- Video Transmission
- Video Coding Standards H.261, MPEG-1, MPEG-2/H.262, H.263/MPEG-4, and H.264/AVC (including SVC)
- Laboratory Excursion (HHI)

---

# Organisation

---

Lecture: Monday 14:00-16:00,  
Einsteinufer 17, Room EN 189

Lecturer: Dr.-Ing. Thomas Wiegand  
Head, Image Communication Group  
Image Processing Department  
Fraunhofer Institute for Telecommunications  
Heinrich-Hertz-Institut  
wiegand@hhi.fhg.de  
<http://iphome.hhi.de/wiegand>

Copies of transparencies can be downloaded at URL:  
[http:// iphome.hhi.de/wiegand/dic.htm](http://iphome.hhi.de/wiegand/dic.htm)

---

# Literature I

---

## *Image Processing Basics*

- A.K. Jain: "Fundamentals of Digital Image Processing", Prentice-Hall, 1989.
- W. K. Pratt: "Digital Image Processing," New York: Wiley 1978.

## *Human Visual System*

- B. A. Wandell: "Foundations of Vision", Sinauer Associates, Sunderland, 1995.
- G. Hauske: "Systemtheorie der visuellen Wahrnehmung", B. G. Teubner Stuttgart, 1994 (in German).

## *Information Theory*

- C. E. Shannon: "A Mathematical Theory of Communication", Bell System Technical Journal, Vol. 27, pp. 379-423 (Part I), pp. 623-656 (Part II), 1948.
- T. M. Cover and J. A. Thomas: "Elements of Information Theory", John Wiley & Sons, New York, 1991.

---

# Literature II

---

## *Rate-Distortion Theory & Quantization*

- T. Berger: "Rate Distortion Theory," Prentice-Hall, 1970
- N. S. Jayant and P. Noll: "Digital Coding of Waveforms," Prentice-Hall, 1984
- A. Gersho and R. M. Gray: "Vector Quantization and Signal Compression," Kluwer, 1992

## *Image Coding*

- M. Vetterli and J. Kovacevic: "Wavelets and Subband Coding," Prentice-Hall, 1995
- W. Pennebaker and J. Mitchell: "JPEG Still Image Data Compression Standard", Van Nostrand Reinhold, New York, 1993.
- J.-R. Ohm: "Digitale Bildcodierung", Springer, 1995 (in German).

## *Journals*

- IEEE Transactions on Image Processing
- IEEE Transactions on Circuits and Systems for Video Technology
- IEEE Signal Processing Magazine
- IEEE Communications Magazine